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(54) CONTROLLING REFRIGERATOR DEFROSTING-APPARATUS

(71) We, N. V. PHILIPS GLOEILAMPENFABRIEKEN, of Emmasingel 29, Eindhoven, Holland, a limited liability Company organised and established under the laws of the Kingdom of the Netherlands, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to automatic defrosting systems for refrigerators, especially domestic and food display refrigerators, but is not limited thereto.

Automatic defrosting apparatus of the kind at present in common use operates on a fixed time cycle so that defrosting occurs at fixed time intervals. However, and particularly in the case of domestic refrigerators, the build-up of frost on the evaporator is quite variable as it depends upon many factors including, among others, the ambient air temperature, ambient air humidity, the frequency with which the refrigerator door is opened and the nature of the goods stored in the refrigerator chamber.

For this reason, a defrosting system which operates on a fixed time cycle is generally inefficient as the fixed interval between successive operations may be either too short or too long according to the particular conditions obtaining. Generally, the fixed time interval is the shortest time likely to be required so that, in most cases, defrosting occurs more often than is necessary and this involves excessive expenditure of power and higher food keeping temperatures because the waste heat absorbed within the refrigerator during each defrost cycle must be removed during the next succeeding refrigeration cycle.

For the foregoing reasons, it has previously been proposed to control automatic defrost apparatus only on demand, that is so that defrosting occurs only when this is required due to an excessive accumulation of frost on the evaporator coil.

It is already known for this purpose to provide a refrigerator with a control system which automatically initiates a defrost cycle when the evaporator coil temperature falls to a predetermined low value.

Such a control system however, is subject to the disadvantage that in some circumstances, for example, when the ambient temperature is low and the refrigerator is only lightly loaded, the evaporator coil temperature may fall to the predetermined low temperature while the temperature in the storage compartment is still sufficiently low and possibly at an optimum value. In such circumstances, an unnecessary defrost cycle would be initiated with consequent wastage of power, and an unnecessary increase would occur in the temperature of the stored food or other material.

Also, in certain other circumstances, for example, if there is a slight shortage of refrigerant, or if the compressor is inefficient, the temperature of the evaporator coil may never fall to the predetermined value required to initiate a defrost cycle. In such a situation, the system would eventually fail due to excessive build-up of frost.

According to the invention there is provided a method of controlling the operation of refrigerator defrost apparatus comprising continuously or periodically sensing the temperature of, or closely adjacent to, the evaporator coil and the temperature of a storage space of the refrigerator, and automatically initiating operation of said defrost apparatus when, the difference between said two temperatures exceeds a predetermined value and, a selected one of said two temperatures is less than a predetermined temperature.

The said storage space may be a freezing chamber or a refrigerator chamber so that in a typical refrigerator of the so-called two-temperature type, the said temperature sensing means for the storage space may be located in or near either the freezing chamber or the refrigerated chamber thereof. Preferably however, this temperature sensing means is arranged in the path of circulated air shortly after it has passed over the

evaporator coil so that in the case of a two-temperature refrigerator, it is advantageously arranged at or near the position at which the cold air enters the freezing chamber.

The invention also provides apparatus for controlling the operation of refrigerator defrost apparatus, comprising means for continuously or periodically sensing the temperature of, or closely adjacent to, the evaporator coil of the refrigerator, means for continuously or periodically sensing the temperature of a storage space of the refrigerator, and means controlled by said temperature sensing means for initiating operation of said defrost apparatus when, the difference between said two temperatures exceeds a predetermined value and, a selected one of said temperatures is less than a predetermined temperature.

Preferably, the duration of operation of the defrost apparatus is controlled by timing means in the known manner, that is to say, the defrost cycles are of uniform duration, though the invention is not limited thereto as alternatively, means also of a kind may be used to terminate the defrost cycle and re-start the compressor when the temperature in the storage compartment rises to a predetermined value, or the evaporator is fully defrosted.

As frost builds up on the evaporator coil, it exercises a progressively increasing insulating effect, so that eventually the rate of heat inflow to the storage space exceeds the rate at which heat is extracted therefrom by the evaporator. In such circumstances, the temperature of the evaporator coil progressively falls while the temperature of the storage space progressively increases, so that, for both reasons, the difference between these temperatures progressively increases. Thus, while the temperature sensing means for the evaporator coil is preferably mounted in contact with the coil, it may alternatively be mounted out of contact therewith but in such close proximity thereto, that during each refrigeration cycle, said sensing means is progressively covered by the layer of frost which accumulates on the coil and is thus insulated thereby from the circulated air.

This temperature difference therefore may be utilised to effect the start of a defrost cycle when the difference rises to a predetermined value.

However, when the refrigerator is being started up for the first time or after a period of disuse, the temperatures of both the storage chamber and the evaporator coil may both be initially at or about the ambient temperature, and in such circumstances, the temperature of the evaporator coil is normally reduced more rapidly than that of the storage chamber so that said predetermined temperature difference may be reached while the temperature of the storage chamber is still relatively high.

Consequently, if initiation of a defrost cycle was determined solely by the said temperature difference, a defrosting cycle could occur during the starting-up operation when it is not only not required, but is undesirable. However, according to the invention, a further necessary condition for initiating a defrost cycle is that the temperature of either the evaporator coil or the storage space, and preferably the latter, is less than a predetermined temperature.

The temperature sensing means may be of any convenient type, for example, thermistors or thermal bulbs, and any appropriate means controlled thereby may be provided for initiating a defrost cycle when the predetermined control conditions are satisfied.

More particularly, the said apparatus preferably comprises an electrical control circuit having two switches connected in series with means operable, when the circuit is completed by the closure of both switches, to initiate a defrost cycle. The said apparatus also includes means controlled by a sensor for the temperature of either the evaporator coil or the storage space for closing one of said switches when the respective temperature falls below a predetermined temperature and vice versa, and means controlled by a sensor for the temperature of the storage space and by a sensor for the temperature of the evaporator coil for closing the other said switch when the difference between such temperatures exceeds a predetermined temperature and vice versa. Consequently, during the defrost cycle, the lastmentioned switch at least, is automatically opened as the temperature differential between the evaporator coil and the storage space, progressively decreases.

Preferably, each of said temperature sensors is a thermistor and each of said switches is preferably an electronic switch to one of which both thermistors are connected, while one of the thermistors is connected to the other switch. Thus potentials, which correspond respectively to the temperature of the evaporator coil and to the temperature of the storage space are continuously applied to one of said switches which is adjusted so as to switch its output from the "0" position to "1" position when the temperature difference increases to the aforesaid predetermined value.

The potential of one of the said thermistors, or of a further thermistor arranged preferably in the storage compartment, is connected to the second electronic switch and when the temperature of this thermistor falls below a predetermined value, this second switch switches to its "1" position.

In order, however, that the invention may be more clearly understood, one form thereof is herinafter more fully described by way of example with reference to the accompanying drawing in which:

Figure 1 is a diagram showing in side elevation certain parts of a typical domestic refrigerator, and

Figure 2 is a diagram of one defrost control circuit according to the invention.

Referring initially to Figure 1, the refrigerator diagrammatically shown therein comprises an outer case 10, a frozen food storage chamber 12 and a refrigerated food storage chamber 14, each of these chambers being normally closed at the front by a door.

The refrigeration system is conventional and includes a sealed refrigerating unit 16, comprising an electric motor and a compressor, an evaporator 18 arranged adjacent to frozen food chamber 12, a condenser 20 and a fan 22 operated in unison with the compressor to circulate the cold air.

The illustrated refrigerator also includes defrosting means including a defrost timer 24.

This timer when actuated, opens switches to effect de-energisation of the sealed unit 16 and fan 22 for a pre-set time interval and also causes a heater 26 to be energized until its circuit is interrupted by a thermostat 28 when the temperature of the evaporator rises to a predetermined value, all in the usual manner.

As previously explained, this invention is concerned with the method of, and means for, starting a defrost cycle and in the illustrated apparatus this is achieved by closing a starting switch (not shown) for the timer 24. For this purpose, the starting switch is controlled by two thermistors 36 and 38 which are connected by conductors 37 and 39 respectively, to electronic control means diagrammatically indicated at 34 in the Figure. These thermistors are of the negative temperature co-efficient (NTC) type so that they develop potentials which increase as their respective temperatures decrease.

The thermistor 36 is arranged in contact with the coil of the evaporator 18 while the thermistor 38 is arranged within the frozen food storage chamber 12.

One suitable control circuit is shown in Figure 2, in which the thermistor 36 is connected in series with a resistance 40 between leads 42 and 43 from the output of a power transformer 44, the lead 42 having a diode 45 and a resistance 46 arranged in series therewith while a zener diode 47 is connected across the leads in parallel with a capacitor 48 to stabilize the voltage applied to the thermistors.

The other thermistor 38 is similarly arranged in series with a resistance 49 between the leads 42 and 43.

The thermistor 36 is connected by a conductor 50 to an integrated circuit forming an electronic switch 52 while the thermistor 38 is similarly connected by conductor 54 to the same switch and is also connected by a conductor 55 to a second electronic switch 56. These two switches are connected in series with a relay driver 60, for example, a silicon controlled rectifier, connected between the leads 42 and 43 in series with a relay winding RL and a normally closed switch 28 controlled by a thermostat responsive to the temperature of the evaporator 18.

The switch 52 is arranged to switch to its "1" rail or condition when the temperature difference between the thermistors 38 and 36 exceeds a predetermined value, and vice versa, while the switch 56 switches to its "1" rail or condition when the temperature of the thermistor 38 is less than a predetermined value, Thus, when both switches are in the "1" condition, the relay driver is activated whereby the circuit of relay winding RL is completed and this relay operates to close the aforesaid starter switch for the timer 24.

During the defrost cycle, the temperatures of both thermistors progressively increase and the temperature difference progressively increases consequent upon the melting of the frost on the evaporator.

Thus, at least the switch 52 switches back to its "0" rail or condition during the defrost cycle and generally the switch 56 also returns to its "0" condition.

However, the relay RL when operated, remains energised until the thermostat switch 28 automatically opens consequent upon the increasing temperature of the evaporator.

De-energisation of the relay RL however, does not cause the timer to be de-energised as the latter includes a by-pass switch which is automatically closed when the timer commences to operate and which remains closed until the pre-set time cycle is completed when the compressor motor and fan are automatically restarted.

It will be evident from the foregoing description however, that during the defrost cycle, the control circuit shown in Figure 2 returns to its original condition with at least one of the electronic switches and usually both of them, in the "0" condition while during the next succeeding refrigeration cycle, the thermostat switch 28 re-closes when the predetermined temperature is reached thus preparing the relay circuit for subsequent operation.

Thus, the invention provides an improved method of and apparatus for automatically controlling refrigerator defrost apparatus so

that defrosting occurs only when this is required due to excessive frost build-up and not, as is usual, at fixed time intervals.

Moreover, the defrost control is directly responsive to the particular thermal conditions which are indicative of a need for defrosting as contrasted with the known demand system which operates when the evaporator temperature falls to a predetermined value and with a known indirect method which involves sensing variations in air flow consequent upon frost build-up.

WHAT WE CLAIM IS:—

1. The method of controlling the operation of refrigerator defrost apparatus comprising continuously or periodically sensing the temperature of, or closely adjacent to, the evaporator coil and the temperature of a storage space of the refrigerator, and automatically initiating operation of said defrost apparatus when, the difference between said two temperatures exceeds a predetermined value and, a selected one of said two temperatures is less than a predetermined temperature.

2. The method according to claim 1 wherein the said selected one of said two temperatures is the temperature of the storage space.

3. The method according to claim 1 or 2, wherein the refrigerator comprises a freezing chamber, a refrigerated chamber and means for circulating air so that it passes over the evaporator and then into the freezing chamber, and wherein the temperature of the storage space is sensed at or near the position at which the circulated air enters the freezing chamber.

4. Apparatus for controlling the operation of refrigerator defrost apparatus, comprising means for continuously or periodically sensing the temperature of, or closely adjacent to, the evaporator coil of the refrigerator, means for continuously or periodically sensing the temperature of a storage space of the refrigerator, and means controlled by said temperature sensing means for initiating operation of said defrost apparatus when, the difference between said two temperatures exceeds a predetermined value and, a selected one of said temperatures is less than a predetermined temperature.

5. Apparatus according to claim 4, wherein said automatic defrost apparatus comprises timing means which determine the duration of operation of the defrost apparatus.

6. Apparatus according to claim 4, including means responsive to the temperature of a storage space of the refrigerator for terminating operation of the defrost apparatus when the temperature of the storage space rises to a predetermined value.

7. Apparatus according to claim 4, 5 or 6, including an electrical control circuit comprising two normally open switches arranged in series with means operable, when energised to initiate operation of said defrost apparatus, and including means responsive to said two temperature sensing means to cause one of said switches to close when the difference between the two temperatures sensed thereby exceeds said predetermined value, and vice versa, and means responsive to a selected one of said temperature sensing means to cause the other said switch to close when the temperature sensed thereby is less than the said predetermined temperature, and vice versa.

8. Apparatus according to claim 7, wherein each of said temperature sensing means is a thermistor.

9. Apparatus according to claim 7, wherein each of said two switches is an electronic switch.

10. Apparatus for controlling the operation of refrigerator defrost apparatus substantially as hereinbefore described with reference to the accompanying drawing.

11. The method of controlling the operation of refrigerator automatic defrost apparatus substantially as hereinbefore described with reference to the accompanying drawing.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

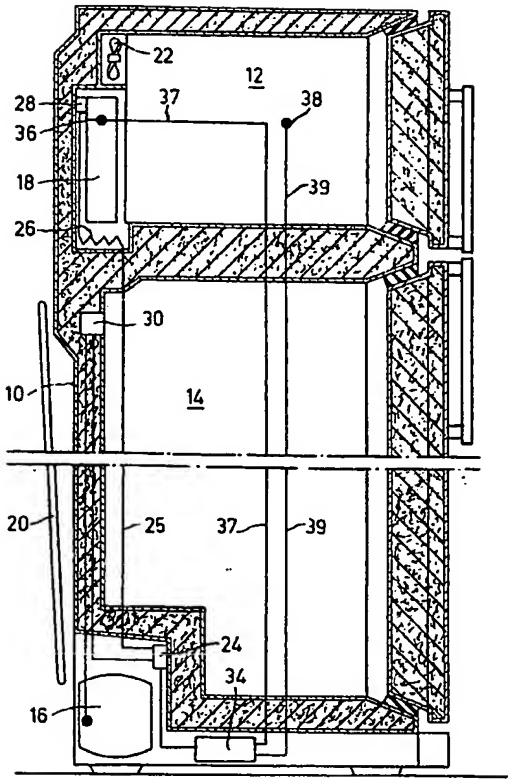

Fig.1

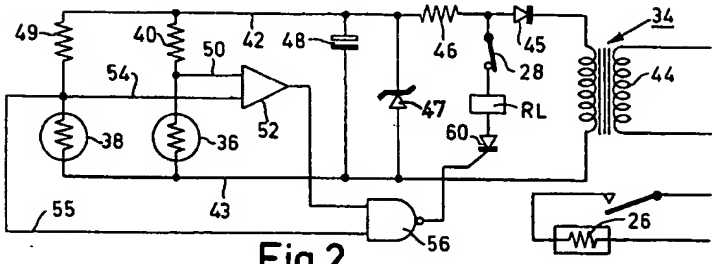

Fig.2